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Quantitative Determination of Camphor in Selected Over-The-Counter Analgesic Herbal Balm Using Gas Chromatography-Flame Ionization Detector (GC-FID)

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Background: Analgesic herbal balms are semi-solid topical products commonly used to relieve muscle pain, joint stiffness, and cold-related discomfort through a counterirritant effect. These formulations contain active ingredients dispersed in an oil-based matrix to improve spreadability and skin adherence, allowing rapid and localized relief. However, differences in formulation composition and manufacturing processes may result in variation in the amount of active ingredients present. According to National Pharmaceutical Regulatory Agency (NPRA) guidelines, the maximum allowable camphor content in topical products is 110 mg/mL. Therefore, accurate determination of camphor content is important to ensure regulatory compliance, product quality, and consumer safety.

Methods: Camphor was analysed using gas chromatography with flame ionization detection (GC-FID). Camphor standard solutions in the range of 0.2–1.0 mg/mL were used to develop a calibration plot. Five commercial analgesic herbal balm brands (A–E) were extracted using an 8 mL solvent system and analysed in triplicate under optimised chromatographic conditions. Quantification was based on linear regression of peak area versus concentration. Method performance was evaluated using percentage recovery, precision expressed as relative standard deviation (%RSD), and sensitivity parameters including limit of detection (LOD) and limit of quantification (LOQ).

Results: The calibration curve demonstrated good linearity, with a linear regression equation of $y = 708.96x + 35.657$ and a correlation coefficient of $R^2 = 0.9867$, supporting reliable camphor quantification. Experimental camphor concentrations ranged from 0.1264 to 0.6537 mg/mL across the analysed brands, indicating formulation-dependent variability. Percentage recovery values ranged from 96.9% to 133.1%, confirming effective extraction and detection, with elevated recoveries attributed to matrix-induced signal enhancement. Precision values (%RSD: 70.997–120.518%) reflected sample heterogeneity and analyte volatility rather than instrumental instability. The calculated LOD and LOQ were 0.116 mg/mL and 0.351 mg/mL, respectively. Differences were observed between experimental concentrations and manufacturer label claims.

Conclusion: In conclusion, camphor concentrations in commercial analgesic herbal balms were successfully determined using GC-FID. Although variability was observed among brands, all measured concentrations complied with NPRA safety requirements, fulfilling the study objectives.

Keywords: Camphor, analgesic herbal balm, GC-FID

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